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[FOURTH SERIES.]

"................. per litora spargite muscum,
Naiades, et circùm vitreos considite fontes:
Pollice virgineo teneros hìc carpite flores:
Floribus et pictum, divæ, replete canistrum.
At vos, o Nymphæ Craterides, ite sub undas
Ite, recurvato variata corallia trunco
Vellite muscosis e rupibus, et mihi conchas
Ferte, Deæ pelagi, et pingui conchylia succo."
N. Parthenii Giannettasii Ecl. 1.

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I.—*On* Stauronema, *a new Genus of Fossil Hexactinellid Sponges, with a Description of its two Species*, S. Carteri *and* S. lobata. By W. J. Sollas, B.A., F.G.S., &c.

[Plates I.–V.]

Oscar Schmidt's remark, "Die Behandlung der fossilen Schwämme durch die Geognosten und Paläontologen ist eine grausliche," has the merit of being strictly true, though in fairness it ought to be added that the geologists and palæontologists are not wholly to blame for this treatment, since most of their work was done before Schmidt's books had been written, before the Hexactinellidæ and Lithistidæ (which would have thrown light on their labours) had been discovered, and at a time, one may add, when the sponges in general were the outcasts of the animal kingdom.

To understand aright the fossil sponges, one must obtain a thorough knowledge first of the minute structure of these bodies themselves, and next of the structure and classification of existing forms. The older observers were without the means of acquiring either of these essentials; they consequently, in their attempts at a classification of fossil sponges, were compelled to fall back upon external characters alone, with the addition of what internal features might chance to be revealed by a happy fracture; and since, as we now know, different genera of sponges may assume the same form, and diverse forms may belong to the same genus or even to the same species, it is easy to see how "dreadful" (grausliche) the treatment must inevitably be which proceeds upon such a basis.

At the present day, however, things are far otherwise with the palæontologists; the microscope and the lapidary's lathe will give us most of the details we require to know concerning the structure of the fossil forms; and as regards the recent ones, we are here still better off since the researches of Carter and O. Schmidt have given us a scientific knowledge of the organization of a vast number of species, and a good working classification of these into orders, families, and genera. The key to the fossil sponges has thus been placed in the hands of the palæontologist; and if he does not henceforth make good use of it, he will fully deserve the censure which Schmidt has passed so severely upon his predecessors.

In consequence of the assistance and advice which I have received from my friend Mr. Carter, I have been encouraged for some time past to work out the alliances of some of the commoner fossil sponges; and, as a result, I am now able to state that *Siphonia pyriformis* and *costata* possess the structure of a Lithistid sponge, and are closely related to the existing species *Discodermia polydiscus* (Bocage) (*Dactylocalyx*, Bowerbank), that *Stromatopora concentrica* and some other species of this genus show no affinities to the Foraminifera, but are Vitreohexactinellid sponges closely resembling *Dactylocalyx pumiceus* (Stutchbury), and that *Manon macropora* and a sponge called *Chenendopora* in the Cambridge Museum belong to the Holorhaphidota (Carter), or sponges whose skeleton consists of acerate spicula closely bound together into a fibrous network. These results, which have been fully confirmed by Mr. Carter*, I hope to publish in full in the course of a few months; while in this paper I shall confine myself to an account of a new genus of the Vitreohexactinellidæ occurring in the fossil state in the Gault of Folkestone.

In examining a collection of various fossils brought by Mr. Jukes-Browne from Folkestone, to illustrate his paper on the Cambridge Upper Greensand, I was much struck with some curious forms, which were said to be *Ventriculitæ* split into halves down the middle; the regularity of the edges, however (which in such a case should have been broken ones), seemed to preclude such an idea, and rather suggested that the forms in question were in a complete state. I wrote therefore to the Folkestone collector, Mr. John Griffiths, re-

* Except with regard to *S. concentrica*; Mr. Carter has shown that some *Stromatoporæ* are allied to *Hydractinia*.

questing him to make me a collection of these fossils; and from his successful search I am now in possession of some forty or fifty specimens, of which some five or six are in a perfect state of preservation, while all exhibit the halfcup-shape form which I had noticed previously.

Outward Form (Pl. I. figs. 1–8).—The sponge is vertically and simply fan-shaped, compressed, single, sessile, and adherent. In size it varies from 3 inches to $\frac{7}{8}$ of an inch in height, from 2 inches to $\frac{6}{8}$ of an inch in breadth, and from 1 inch to $\frac{3}{8}$ of an inch in thickness. The object on which the sponge grew is generally a small fragment of coprolite (Pl. I. fig. 6, *b*), which in good specimens still remains adherent at or near the point from which the sides of the fan diverge. This point indicates, then, the "base" of our sponge; and it follows that the diverging sides of the fan are the "lateral" edges, and the curved side which joins them, subtending the angle at the point below, is the "distal" or upper margin. The sponge is curved from side to side, the lateral margins being slightly approximated, so as to make the fan concave from side to side like a half-cup or hollow half-cone. The concave is the "anterior" or "interior," and the convex the "outer" or "posterior" surface.

General Structure.—The sponge is composed of two obvious parts—a thin plate in front (Pl. I. fig. 1, *o*), and a thick protuberant mass behind (ibid. *p*); a distinct seam (*s*), which may be merely a line produced by the approximation of the skeletons of the two, or which may be deepened into a shallow groove, defines these two parts from one another along the lateral edges: on the posterior surface the distinction is manifest by the free projection of the anterior plate beyond and above the posterior protuberance (Pl. I. fig. 2, *o*); and in fractured specimens the distinction is seen to be continued within (Pl. II. figs. 1, 2), the two structures, however closely apposed, seldom if ever merging into one another.

Anterior Plate.—The surface of this is even and smooth, its thickness from back to front tolerably uniform, but slightly increasing as it grows upwards from the base; in a specimen $2\frac{1}{2}$ inches high by 2 inches broad and $\frac{5}{8}$ inch thick it measures $\frac{1}{5}$ of an inch at the summit, and at the base a little less than half this amount. The ratio of the thickness of the plate to the other dimensions of the fossil varies widely with different specimens.

The plate projects freely above the posterior protuberance, and terminates in a broken distal edge. This is the case with all my specimens. The anterior plate has been broken off, either down to the level of the posterior mass or at a short distance above it, the maximum distance I have measured being $\frac{1}{4}$ inch.

As, then, the normal distal margin has not been seen in a single specimen, one is unable to say how much further it originally extended: it may have terminated close to its present level, though, from the abrupt way in which it is fractured, it more probably reached some distance above; or it may have been continued into a large flabelliform expansion, thinning away above and many times larger in area than the portion now remaining—in which case this plate would be the really essential sponge, and our fossil merely its base overgrown with the posterior mass; and the probability of this view derives support from the fact that I have in my possession a thin plate of fossil sponge (Pl. I. fig. 9), 5 inches long by 4 broad, and from $\frac{1}{8}$ to $\frac{1}{10}$ inch thick, curved from side to side, and exhibiting, as we shall see presently, every structural peculiarity to be found in the anterior plate of our fossil. Whether this is really a continuation of the anterior plate can only be demonstrated by finding a specimen in which the latter actually passes into such a flabelliform expansion; and for such a one I have directed Mr. Griffiths, of Folkestone, to make a search.

The front face of the anterior plate is a plain surface as far as the level of the posterior protuberance; but beyond this, where it begins to project freely, it is marked by a number of round, or more usually oval, oscular pits arranged quincuncially (Pl. I. fig. 1), and on the whole constant in size and distance from one another in the same specimen, but differing in both these respects in different specimens (Pl. I. figs. 1 & 3). The variations in size may all be comprised between the extremes of $\frac{1}{10}$ and $\frac{1}{30}$ inch for the length of the major axis of the ellipse.

The posterior face is of course covered below by the posterior mass; but above, where it is exposed, it generally exhibits a number of oval spaces arranged quincuncially and closely resembling the oscular pits in front (Pl. I. figs. 2 & 8), a little less regularity in arrangement and a thickening of the intervening structure into irregular ridges in the case of the posterior markings constituting the only difference, and that not a constant one, between the two. Sometimes the free posterior face is smooth, like the lower part of the anterior face.

When the anterior plate is broken across, one may see the oscules of its anterior face prolonged into cylindrical tubes, which pass inwards normal to the surface, and, receiving irregular lateral canals in their course, terminate in the oval spaces which mark, as we have seen, the posterior face, and which probably served as the special pore-areas of the sponge. This arrangement accords with the general rule, that in all cup-shaped and curved fan-shaped sponges the oscules are placed on the interior surface of the cup or on the concave surface of the fan, while the pore-areas occupy the outer or convex surface in each case.

The restriction of the oscules to the free part of the anterior plate is only to be seen in tolerably perfect specimens; in those which are at all worn or much weathered the oscules are exposed all over the anterior surface, and by no means confined to its freely projecting part. The absence in this case of the smooth face below, and the appearance of oscular markings in its stead, is evidently the result of attrition, and suggests that beneath the smooth surface of unworn specimens the oscules may still exist, but concealed by a superficial coating: a slight examination will set this beyond doubt. In some instances a small patch of the outer coating has been completely worn away, while the rest of it has simply been much diminished in thickness; we then see the oscules freely exposed over the denuded area, and dimly to be discerned through the thin coating which remains: in perfect specimens the smooth surface may be removed by dissolving the calcareous matrix of the fossil with acid, and brushing away the superficial network which remains behind; the oscules are then clearly revealed; while, finally, if a section be made across the plate, the tubes which lead directly away from the oscules will be seen traversing it at right angles to the exterior coating (Pl. I. fig. 2, *e'*, and Pl. II. fig. 1, *o*, fig. 2, *o*).

The anterior plate thus possesses the same essential structure throughout; it is a thin plate perforated completely by a number of parallel cylindrical tubes or excurrent canals, which traverse it at right angles and terminate in front in oscular pits, and behind in pore-areas. Its projection past the posterior protuberance shows that it is the first formed of the two structures; and it would appear that as it extended itself vertically and laterally the posterior mass followed after it for some distance as an aftergrowth, while at the same time a superficial covering coated it correspondingly in front, concealing the oscules beneath, perhaps converting them into pore-areas, and leaving patent those only on the projecting part above.

Posterior Mass.—The posterior part forms a compact mass (Pl. I. figs. 2, 4, 6, 7, 8, Pl. II. figs. 1 & 2), which, unlike the oscular plate, rapidly increases in thickness from below upwards and from its edges to the middle of its face; so that in a specimen $1\frac{1}{4}$ inch high, with an oscular plate uniformly $\frac{1}{8}$ inch in thickness throughout, it has increased from a mere trifle at the base and the edges to $\frac{5}{8}$ inch at the top and through the middle of its face. In contrast also with the uniform character of the oscular plate is the irregularity of growth manifest in this portion: in one class of forms it increases in a series of bulgings, which form gently rounded swellings concentric with the distal margin, or rounded ridges so regular as to give the hinder surface a corded appearance; sometimes the gentle swellings are not continuous but sink laterally into faint dimples; while the ridges are not always semicircular, but occasionally change their course abruptly so as to be V-shaped at one side.

Above, the upper surface of the posterior mass may be gently rounded against the oscular plate, or it may form a flat table and join the plate at right angles.

Underlying the variations in this class of forms there is, however, a certain degree of regularity; in all the posterior mass extends laterally as far as the oscular plate, and the two are conterminous along the lateral edges, whilst above, whether it joins the oscular plate gradually or abruptly, it always follows the general curve of the latter in a simple or nearly simple line. But in another class of forms, which, I think, constitute a separate species, the irregularities are much greater than the foregoing; in them the posterior mass is seldom ridged concentrically, but soon after leaving the base it becomes lobed vertically into two or more diverging processes, differing in size and shape, and exposing the oscular plate in the angle between them: in these forms the posterior mass reaches the lateral margins of the sponge near the base only, and soon ceasing to do so as it ascends, allows the anterior plate to extend freely beyond it in a lateral as well as in a vertical direction.

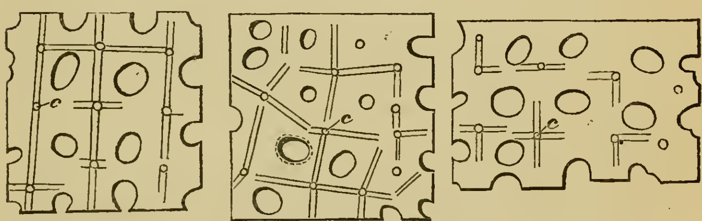
Externally the porous mass presents a plain surface, never excavated by oval pits or specialized pore-areas. In section it exhibits a number of canals, which, passing from the interior in a more or less wandering course, and without any regular arrangement, terminate at length against the attached face of the oscular plate, into the excurrent canals of which they in some cases directly open; but whether they do so always seems to me doubtful.

Minute Structure.—To investigate this the fossil may be prepared in two ways: it may either be treated with some acid (I prefer nitric) by which the matrix of calcite is readily dissolved, while a siliceous network is, in well preserved specimens, left in relief; or slices may be cut from it and ground down till thin enough to be transparent; this is the method to which I have chiefly trusted, only using the former when the latter has not been available. The sections I have had made have been taken along the following planes :—(1) longitudinal and at right angles to the surface, both through the centre and nearer the sides—longitudinal sections (Pl. II. fig. 2) ; (2) transverse and at right angles to the surface—transverse sections (Pl. II. fig. 1) ; (3) parallel to the surface, one through the oscular plate and another through the posterior mass—parallel sections (Pl. II. fig. 1, *b*, *c*, fig. 3).

The appearances of these sections under the microscope I shall now describe, and in so doing shall confine myself first to an account of the skeletal structure which they demonstrate, referring most of the facts which bear on the mineral characters to a subsequent paragraph.

Each of the sections we have defined shows a regular network of fibres arranged in the following manner. Selecting a single node in the net we observe four fibres, usually siliceous, radiating from it at right angles to one another in the form of a cross (figs. 1, 2, 3) ; each is perfectly continuous

Fig 1. Fig. 2. Fig. 3.



Sections taken through the oscular plate of *Stauronema Carteri*, from the specimen represented in transverse section on Plate II. fig. 1 ; all magnified 30 diameters. Fig. 1. Longitudinal section (*a*, Pl. II. fig. 1). Fig. 2. Transverse section (Pl. II. fig. 1). Fig. 3. Parallel section (*c*, Pl. II. fig. 1).

with similar fibre from an adjacent node, and has at its greatest distance from the two nodes it connects (*i. e.* at a point midway between the two) a diameter of $\frac{1}{120}$ to $\frac{1}{180}$ of an inch ; but on approaching the node it thickens considerably so as to fill up the angles of the cross and round them off : in this way the meshes of the net, which, from the disposition of the nodes, would otherwise be rectangular, are always round or oval ; and these rounded spaces, which are bounded by the outer margins of the fibres, are so sharply defined as to enable us to state with certainty that the fibres themselves are perfectly smooth and not in any way spined.

In the centre of the node is a small and very definite circle, $\frac{1}{50}$ to $\frac{1}{500}$ inch in diameter (figs. 1, 2, 3, *c*), which is produced by the section crossing at right angles a cylindrical tube, originally hollow, but now generally filled with carbonate of lime; and from this radiate four similar cylindrical canals, one in the axis of each arm of the cross; these, of course, are seen sideways and not end on, and ordinarily they are continuous from one node to another, like the fibre in which they are excavated. As these appearances are to be seen equally in each of three sections taken at right angles to each other (figs. 1, 2, 3), it is clear that our quadrilateral cross of fibre is really a sexradiate one (fig. 4), with its arms arranged about three

Fig. 4.

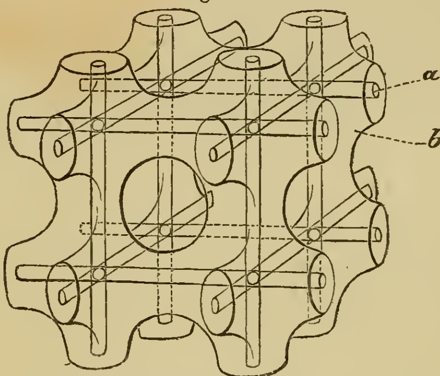


Diagram of the network of *Stauronema*. Scale 60 : 1. *a*, sexradiate canal; *b*, sexradiate fibre.

axes at right angles to each other, and that corresponding with the axes interiorly is a similar sexradiate hollow canal.

Now this structure is exactly that which characterizes the rete of the Vitreohexactinellidæ, and may be seen to perfection, with differences merely as to detail, in deciduous skeletons of *Farrea* and *Aphrocallistes*. In these genera, as in the Vitreohexactinellidæ generally, the skeleton is produced by a growth of siliceous matter over sexradiate spicules; and in *Farrea occa* each node of the resulting network is a rectangular sexradiate cross of fibre, which has formed about a sexradiate spicule, which thus comes to occupy the centre of the fibre. In many vitreous hexactinellids the fundamental spicule is preserved imbedded in the siliceous fibre, which is thus originally solid; and which, as it is composed of the same material all through, without any difference of refractive index, cannot be distinguished into spicule and fibre, but appears homogeneous throughout. But in deciduous specimens of *Aphrocallistes* and *Farrea* the original spicule undergoes a process of absorption and disappears, leaving in its place a hollow sexradiate cavity readily observable in the interior of the fibre. Our sexradiate fibre has, then, in the fossil condition a structure essentially identical with that of the recent skeleton of *Farrea* when in a deciduous state. The siliceous fibre of our fossil corresponds with the siliceous fibre of *Farrea*; and the sexradiate canals in its interior correspond with the hollow casts of the spicules in the latter: the only difference is that the canals in our fossil are continuous from one node to another, while in recent Hexactinellidæ they terminate blindly, as casts of spicules naturally would, their blind terminations generally overlapping one another *. But even this difference vanishes with a close examination of the fossil fibre, as I shall show when we come to speak of the various modes of its fossilization.

The characters of the sponge already described are sufficient to define the genus, which I now propose to call "*Stauronema*," from the cross-like disposition of the thick skeletal fibres about the nodes of the network, a feature readily visible under a common hand-lens. In the oscular plate the nodes of the network are usually arranged symmetrically at equal distances from each other, so as to form meshes which would be cubical but for the thickening of the fibre towards the node, which converts the cubes into spheres or ellipsoids. By reason of the symmetrical grouping of the nodes, the skeletal fibres fall into three series:—one longitudinal, ascending from the base; a second horizontal, radiating from the imaginary axis on which the half-cone of the sponge may be supposed to be described; and a third horizontal and concentric with the curve of the fan.

The longitudinal fibres (Pl. II. fig. 4, *l*) deviate from a parallel course by diverging, as they rise from the base, towards the anterior and posterior faces of the plate; and to maintain the uniform size of the meshes, fresh sexradiate elements are interposed in the same way as I have described in *Eubrochus* and the Ventriculites †. The radiating fibres, since the curve of the fan is gentle and the oscular plate thin, lie in almost parallel lines; but both they and the concentric

* [As the absorption goes on, the form of the spicules becomes lost, and that which remains is a simple cylindrical cavity, which led Bowerbank to say that the fibre of *Farrea* was channelled like that of the Ceratina, ex. gr. *Luffaria*.—*Note by* Mr. Carter.]

† Quart. Journ. Geol. Soc., Feb. 1873, p. 66, fig. 4; Geol. Mag., Sept. 1876.

fibres are not, strictly speaking, confined to horizontal planes; for they curve upwards in gentle arcs so as to suggest that they once bounded and corresponded with the rounded edge which in all probability terminated the distal margin of the plate, in the same way as a similar edge now limits its lateral margins.

The oscules and excurrent canals are arranged so regularly in the plate that they do not disturb the regularity of the foregoing arrangement to any great extent, though in their immediate neighbourhood the sexradiate nodes become grouped round the excurrent canal, so as to be subordinate to it rather than to the general structure; thus some of the nodal crosses are turned round 45° out of their normal position, so as, in joining with the others, to surround the circular canal with continuous concentric fibres; and, at the same time, the fibres actually forming the walls of the canal are both bent and thickened in order to bring about their complete adaptation to its circumference. These facts may be seen in sections, but better perhaps by etching the oscular surface with acid, when, on the solution of the matrix, the oscular network stands freely out in relief, and with its slightly expanded termination resembles in miniature the mouth of a waste-paper basket; one can then see, by looking down into it, by reflected light, the adaptation in the arrangement of the nodes and the bending and thickening of the fibre, from which results a circular network with circular fibres forming the walls. One will also discover that the oscular fibres are beset with rather short conical spines (Pl. III. fig. 1), which sometimes are simply spinous outgrowths, but frequently also the sixth arm of a nodal radiation, which, instead of passing into the network as usual, points freely into the excurrent canal, just as happens in the canals of *Aphrocallistes*. In direction they usually incline outwards and towards the centre of the excurrent canal, but not always; in exceptional cases they are turned inwards, and then seem to be related to the fine canals which open in the meshes of the oscular network, since they spring from the sides of the fibre about such a space, and point into the excurrent canal. With this modification the rule here, then, as in *Aphrocallistes*, seems to be that the spines always point in the same direction as the outflowing current which at one time passed by them. It is possible that this arrangement indicates a defensive function for these spines; but, as an explanation of their position, one may recur to the fact that Carter has traced the development of the spicule from its mother cell *, and

* Ann. & Mag. Nat. Hist. 1874, vol. xiv. p. 97, pl. x.; 1875, vol. xvi. p. 11.

shows that the sexradiate forms are in all probability produced by a radiate growth from the first of the six arms from a common centre: this being so, one can readily see that if the growth of a free radius took place in the course of the excurrent canal, it would be subject to a pressure in two directions at right angles to each other—one due to its growth onwards, normal to the surface from which it springs, and the other parallel to the axis in the direction of the current; and its ultimate position would be the resultant of these two, and would be in just such a position as the spines, in fact, assume.

The growth of the spicule from a mother cell also explains in part many other matters which would otherwise be enigmatical. Thus the wonderful regularity of the network we have previously described may be looked upon as having resulted from a mother cell which originally gave off buds, one at the end of each of its spicular rays—*i. e.* in the direction of most active growth; the cells so budded off would become in turn mothers, and repeat the process, till, by reason of the limitations imposed by the limits of the organism, they would be unable to produce more than one bud each, and that vertically—except that when the distance between two cells became much greater laterally than twice the length of a spicular ray, a fresh cell would thus appear at the side of one of them, and the vacant place be filled up.

Detached Oscular Plate.—The thin plate of sponge-structure mentioned on p. 4 is bounded on all sides but one by a broken edge; the edge which is not broken is one of the lateral margins, neatly rounded off in the same way as are the sides of the oscular plate in *Stauronema* (Pl. I. fig. 9, *n n n*). Anteriorly the plate is marked by oscular pits (fig. 9, *a*) quincuncially arranged, and of the same shape, size, and distance from one another as in *Stauronema.* These pits are the mouths of cylindrical excurrent canals, which perforate the plate and open posteriorly in rounded pore-areas. The structure intervening between the pore-areas is frequently raised into ridges and prominent monticules, more marked than those which occur on the posterior surface of *Stauronema*, but otherwise similar; the skeletal networks of both fossils have also the same structure and arrangement; and their meshes and fibre are of the same dimensions. These facts, and the absence of the true distal margin of the oscular plate in the other specimens, leave little doubt in my own mind as to the relation which this fossil bears to the latter. I cannot but regard it as a part of a distal expansion of the oscular plate of *Stauronema.*

Posterior Mass.—Between the canals of the posterior mass is distributed a skeletal network similar to that of the oscular plate. The central sexradiate canal, which is the fundamental part of the skeleton, is of the same size and regularity in both; and in one specimen the sexradiate nodes are disposed with a regularity so great as to bring about a general arrangement of the fibres into more or less longitudinal, concentric, and radiating series. But this arrangement, owing to the want of regularity in the course of the canals, is more frequently disturbed by adaptation; the sexradiate spicules are often turned at various angles from what would be their normal position; and of course the fibre follows them, with the result that the arrangement of which we spoke is often nothing more than a tendency to an arrangement; while in most specimens even this amount of regularity would be hard to trace, the sexradiate character of the network almost vanishing or only to be detected in the infallible sexradiate canals.

Superficial Reticulation.—On examining the front face of the anterior plate, there may be seen, in favourable sections, a layer of finer but less regular network proceeding from the outermost meshes of the general skeleton, which lie immediately beneath; and, again, outside this *secondary* rete, as we may term the finer network, a very thin layer of structure may be sometimes observed, so minute and confused that in section nothing intelligible can be made of it, and for its successful examination one must have recourse to the method of etching with acid.

When the face of the attached oscular plate is examined by reflected light in its natural state, it presents a plain surface, the smoothness of which is only disturbed by a faint tubercular appearance; but on dissolving away its calcitic matrix with nitric acid, a beautiful siliceous network is exposed, which may be best examined under a power of about 100 or 150 diameters, and by reflected light. One may see then, in places where the network has wholly broken down, the coarse skeleton-fibres with their nodes forming a layer immediately beneath, and in this position very commonly furnished with short, erect, conical spines (Pl. III. fig. 3); above this follows a layer of similar network, but much smaller in mesh, a little less regular, also spined but more abundantly (Pl. III. fig. 3, Pl. IV. figs. 1, 3): four arms of the sexradiate nodes of this network, which we have observed in section as the secondary rete, lie parallel to the surface in square meshes; of the other two, one passes inwards and joins the general skeleton, and the other projects outwards, normal to the surface, like the "fir-cones" in *Farrea occa.* These free projecting arms all end at about the same level in cylindrical rounded spinose terminations (Pl. III. fig. 2); but now and then these terminations are wanting, and the quadrilateral meshes from which they spring lie level or nearly level with the surface. From the spinose ends, or from the quadrilateral meshes, an exceedingly fine network of delicate, glassy, pullulating fibrelets is given off, which fills up the interstices of the secondary rete (Pl. III. fig. 4, Pl. IV. figs. 4, 5, 6, 7, Pl. V. fig. 4); frequently it is wholly irregular, but in numerous instances exhibits the true sexradiate arrangement. Its meshes and fibrelets vary in size, the average measurement from node to node being $\frac{1}{700}$ to $\frac{1}{1000}$ inch, and the diameter of the fibres $\frac{1}{1500}$ to $\frac{1}{3000}$. Thus the latter are, as a rule, not appreciably thicker than the spines of the secondary rete: and this suggests that some of these spines may be, after all, nothing but the attached parts of fibrelets, which have been broken off or dissolved away; and often a series of gradational forms can be traced, proving that some are of this nature; but many, from their smooth sides, regular conical form, and abundance in places free from fibrelets, must, as we have already considered, be true spines.

From the minuteness and proximity of the sexradiates one would conclude that they have been coated merely with a thin film of siliceous material, or are only soldered together at their ends; and the same characters would also lead us to infer that they do not afterwards come to form a part of the interior skeleton, but remain as a surface-coating, which must be regarded as an aftergrowth creeping over the oscules of the anterior plate, as this becomes overgrown by the posterior mass behind.

Though this network is in general collected only about the ends of the radii from the secondary rete, beneath or between the meshes of this rete, it yet also happens occasionally, especially near the base, that it accumulates in patches to a much greater extent, burying up the network below, so as to completely conceal it from sight (Pl. IV. fig. 4), and forming a low but distinct mound above the general surface, and even, in one case, producing a series of rounded ridges (Pl. I. fig. 2, Pl. II. fig. 2, *r*) which pass straight across the anterior face of the oscular plate, horizontally from one side to the other.

The superficial network, where it covers up the oscules, descends some distance into the excurrent canals, as may be well seen by breaking a specimen across the oscular plate, etching the fractured surface, and then examining it by reflected light. The skeleton-fibres, with their projecting spines, are then exposed; the superficial network is seen covering over the oscular opening, and giving off one or two pendent processes into the excurrent canal; and, moreover, the skeletal fibres which surround the canal are also produced into outgrowths of delicate reticulation and irregular fibres which straggle across the canal from side to side (Pl. III. fig. 2); and the tendency of the fibre to pass into secondary growths thus manifested is carried so far that, even in the normal smooth network not immediately surrounding the canal, an occasional spine puts in an unexpected appearance.

The superficial network does not frequently occur over the posterior mass; and its rarity in this position appears, in some cases, to result from the wear and tear to which a convex surface like that of the posterior mass is especially exposed; in other cases it is due to a less favourable state of fossilization than obtains in the anterior plate; while in others still it would appear to be absent because the posterior surface has never been furnished with it, which last, indeed, is only what one would expect on the view that the posterior mass is an aftergrowth which increases behind while the aftergrowth of fine network is extending itself in front. It is only when the posterior mass has, like the attached anterior plate, ceased to grow, or, at all events, when its growth has for a time been arrested, that one would expect to find a final overgrowth of fine network on its surface. Such a layer I have met with in one case only, though whether it is, in this particular instance, exceptionally produced or exceptionally preserved, is of course impossible to say. This network, under a magnifying-power of 50 or 60 diameters, appeared to be without a sexradiate arrangement, its meshes not having any very regular form, and each of its fibres seemed to be pitted or perforated with a number of minute holes (Pl. V. fig. 1); but when a power of from 100 to 140 diameters was applied, it was found that these minute holes were the intermeshes of a delicate net, and that each fibre was itself a complex reticulation of exceedingly delicate fibrelets (Pl. V. fig. 2), which, where most perfectly preserved, showed a regular sexradiate disposition, with nodes distant $\frac{1}{1250}$ to $\frac{1}{2000}$ inch from each other, and fibre $\frac{1}{1500}$ to $\frac{1}{8000}$ inch in diameter. Where a sexradiate arrangement could not be detected, the defect appeared to be owing to the disappearance of some of the fibrelets necessary to the arrangement, by solution or otherwise. The cylinders of network exhibit sometimes a central axis of solid fibre from which the finer rete is given off all round; and sometimes they pass into a solid fibre ornamented with projecting fibrelets—a transformation apparently due to the fusion of the compound network-fibre into a solid one by the further deposition of siliceous matter. Between the open meshes of this most exquisite net (which, in the delicate and complex tracery of its transparent fibres, surpasses almost every thing I have seen amongst the Hexactinellidæ) one observes either an intermesh perfectly open and leading to the interior of the skeleton, or else a multitude of minute glistening fibrelets, which pass from fibre to fibre of the secondary rete below, and weave across its meshes a transparent vitreous web (Pl. V. fig. 3). The secondary rete passes in its turn into the skeletal network below, which, at first beautifully spined, soon becomes, as it leaves the surface, perfectly smooth.

The foregoing facts could be observed by examining the surface of the etched fossil by reflected light; but by splitting off a few fine chips with a scalpel, treating them with acid in a watchglass, washing with distilled water, and finally drying, the network could be obtained in a state fit for mounting in Canada balsam and other media, and for observation with transmitted light.

Traces of the network with complex fibres may be detected along the lateral edges of the oscular plate in the specimen where it occurs; but further on, over the anterior face, it quite vanishes, and only the ordinary superficial reticulation prevails (Pl. V. fig. 4).

Flesh-spicules.—The perfect manner in which the superficial network is preserved led me to think that some rosettes or other flesh-spicules might perhaps be seen in the sponge; and the most likely places to look for them appeared to be, first, in the residue set free in suspension on treating the fossil with acid, and, next, in the open meshes of the skeleton. A careful examination of the former proved altogether unsuccessful, while in the latter iron pyrites was observed under a variety of forms. In this there was hope, since I have slides showing minute coccoliths and delicate radiolarians perfectly preserved in this material: therefore I made a long search in the expectation of finding some form of iron pyrites which should display evident traces of the rosette form; but, with a few very unsatisfactory exceptions, my search was quite in vain. The flesh-spicules of the Hexactinellidæ have yet to be found in the fossil state.

Other Spicules.—I have, however, met with two spicules other than sexradiates in this fossil. One is a completely erectly spined cylindrical form (Pl. V. fig. 5) with one part hidden in the network, from which the other portion projects freely, making an acute angle with the oscular surface as it points upwards from the base. This spicule bears a close resemblance to that figured by Bowerbank * from *Aphrocallistes* (*Iphiteon*, Bk.) *beatrix*.

The other spicule occurs in a parallel section of the oscular plate, as a cast, partly hollow, partly filled with iron pyrites; it is simple, not spined, terminates so obscurely that its ends cannot be made out, and is imbedded in skeletal fibre in company with the ordinary sexradiate spicules (Pl. V. fig. 5).

Modes of Fossilization.—The fossilizing material is usually crystalline transparent carbonate of lime, or calcite, which fills up the meshes of the network, and occupies the sexradiate canals of the siliceous fibre; where it occurs in large quantity, as in the meshes and excurrent canals, it is traversed by numerous cleavage-planes; and it is usually impure from the presence of a little aluminous matter. The fibre thus enclosed consists of silica, and in a few cases is almost as homogeneous and purely siliceous as when it existed in the living state; but even in this, its most perfect condition it generally exhibits the marks of decay, not only by the absorption of its interior spicule, but in the presence of numerous hemispherical pits excavated from its exterior to various depths, like those described by Carter as affecting recent spicules †; from this condition it soon passes through a series of changes, the final result of which is to leave it wholly converted into carbonate of lime. The first step in the process is a granulation of the fibre about the internal canal, which soon extends itself, chiefly by eating its way from within outwards, till at length it reaches the outer boundary of the fibre; and this, which during the process of change has retained its definite outline, often its transparency as well, yields at last, and the fibre becomes granular all through. The granulation, however, also frequently appears at the outside and the inside of the fibre at once, and proceeds from each direction till it meets in the interior. While the granulation is thus progressing, a process of absorption is set up about the interior canal, accompanied by a replacement of the fibre in carbonate of lime; this change takes place from within outwards, and continues till at length a mere shell of rounded granulations of silica separates the calcite without from that within the fibre; finally this shell itself disappears, and the exterior and the interior calcite become one. But even then, with this extreme mineralogical change, the original structure is not obliterated: the calcite which fills the internal canal and the interspaces of the meshes is transparent and usually colourless, or with a faint yellowish

* Proc. Zool. Soc. 1869, pl. xxii. fig. 9.

† Ann. & Mag. Nat. Hist. ser. 4, vol. xii. p. 457.

tinge; while that which replaces the siliceous fibre is, by reflected light, of a milky blue colour, and by transmitted light brownish, less transparent, and granular with dark spots. And thus while the fundamental spicule has become absorbed, and its hollow cast filled with crystalline calcite, and the same material has replaced the siliceous fibre and the sarcode between the meshes—while, in fact, the whole of the metamorphosed net consists of one material, carbonate of lime, the structure is yet left as definitely recorded as in a sponge with its natural composition only just dead; and from this striking fact is forced upon us the conclusion that in determining the characters and affinities of fossil sponges, the mineral composition is an argument of but fifth-rate value, and the form and structure here, as in most other anatomical questions, is the one thing important.

It frequently happens that while the sponge towards the exterior is preserved in calcite, it is fossilized with silica in the interior; and between these two conditions one can often trace a series of transitional changes. Thus in one specimen the sharp outline of the siliceous fibre soon disappears as it proceeds inwards, and is replaced by a botryoidal surface of hemispherical bosses (p. 18. fig. 6, *a*; p. 19. fig. 7, *a*), each with a corresponding cavity on the inside; from the botryoidal exterior a fibrous crystallization of silica radiates towards the middle of each intermesh *, filling it up; the interior of the fibre, on the other hand, is occupied with clear transparent calcite exhibiting cleavage-planes, and the sexradiate canal is filled with silica, crypto-crystalline, and exhibiting patches of colour when polarized light is passed through it. Thus the original siliceous spicule is, after a cycle of changes, restored again to the siliceous state. And here one may notice the very important fact that these pseudomorphic spicules are not continuous with each other, but remain perfectly distinct, with their rays overlapping, precisely as they do in *Farrea* and *Aphrocallistes* (fig. 5, *a*). In one or two instances (fig. 5, *b*) four spines equally distant from each other have been noticed surrounding the proximal end of each ray, and pointing towards the centre of the spicule—thus indicating that in these cases a hollow process, now converted into a spine, once proceeded from the central canal and entered the thickening of fibre which fills up the angles at the nodes of the network. If, as might easily happen, these canals underwent an extension so far into the thickening as to meet one another, and become continuous, we should have a structure singularly homoplastic with that of

* "Intermesh," the space included between a mesh.

the Ventriculite lantern. I notice, however, in addition to the four spines just mentioned, others (fig. 5, *c*) which appear to radiate from the centre of the spicule, one between each angle of the rays; so that altogether the structure is a very puzzling one, and difficult to work out, because I find no other clear example of it.

Fig. 5.

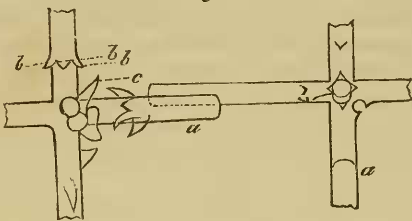


Fig. 5. Siliceous casts of sexradiate canals of *Stauronema*: *a*, overlapping rays; *b*, three accessory spines; a fourth is concealed on the opposite side of the ray; *c*, spine projecting from the centre of the cast.

As the skeletal network is traced further inwards, the calcite inside the fibre becomes replaced by silica (fig. 7), and the silica which represents the original spicule by iron pyrites (fig. 7, *b*).

Fig 6.

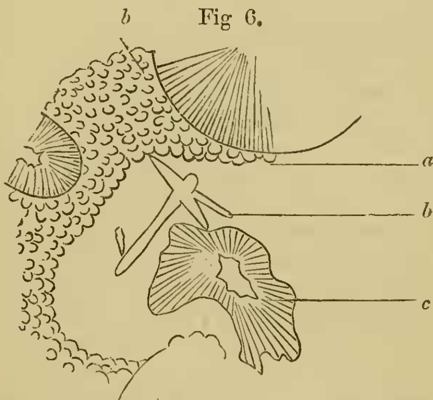


Fig. 6. *a*, botryoidal surface of fibre replaced by calcite; *b*, siliceous cast of spicule; *c*, radiately crystalline silica of intermesh.

The original fibre then vanishes altogether; the botryoidal surfaces no longer define it, but, growing far away from their original position and nearer to one another, diminish the intermeshes into a narrow fibre-like reticulation, and widen the fibres into broad mesh-like spaces; and we can only distinguish the site of each by the fact that the botryoidal surface always presents its bosses towards the meshes and away from the interior of the fibre; to which distinction may be added another, which consists in the fact that the silica deposited *viâ* the fibre is never fibrous like that deposited outside, but gives merely a mottled appearance of colour with polarized light. By this we know that the sexradiate spicules of iron pyrites are truly inside the fibre, as we should expect, and not outside, as they appear to be. Here, again, we find a want of continuity between the rays of neighbouring sexradiate spicules, which come to an end abruptly and overlap without passing into one another.

Fig. 7.

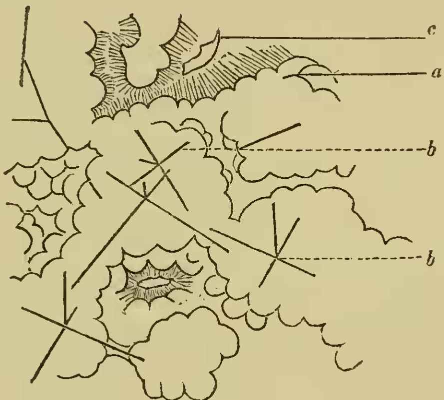


Fig. 7. *a*, botryoidal surface of silicified fibre; *b*, casts of spicules in iron-pyrites; *c*, radiately crystalline silica of intermesh.

Iron Pyrites.—This, as we have seen, fills the central canals when the fibre is replaced by crystalline silica; but it does so as well when the fibre retains its original state and when it is converted into carbonate of lime. It is always granular—so much so, that fine spicular rays are sometimes composed of nothing but its spherical concretions set in a linear series. The pyrites is not confined to the canals, however, but forms bacilli, spherules, and granules in the fibre itself, both when the latter retains its original siliceous state and when it is wholly changed into calcite. It is, moreover, found in the intermeshes, taking frequently the form of globular concretions, which are covered on the surface with crystalline facets, like the iron-pyrites concretions of the chalk seen in miniature; in size these globules are about $\frac{1}{700}$ inch in diameter, and may perhaps have formed about the rosettes which surely once existed in the sponge.

Change in Refractive Index of the Silica of the Fibre.—When fragments of the siliceous network are freed from calcite by means of acid, washed, dried, and mounted in Canada balsam, the fibre is found to be characterized by a remarkable transparency, often so great as to render it almost invisible; and this is perhaps partly to be explained by attributing to it great porosity, by which the balsam would be able to penetrate it everywhere, and great transparency would result; and this view is supported by the fact that the fibre in the dry state, and mounted in air, appears of a pure snowy white by reflected light. But I scarcely think this is the whole explanation, since when such prepared fibre is mounted in glycerine jelly, its transparency is much diminished, and consequently it can be seen with greater distinctness. Now glycerine jelly has a much lower refractive index than Canada balsam; and hence these different appearances can be readily explained by supposing that the silica of the fibre has a refractive index nearly equal to that of the balsam, but higher than that of the glycerine jelly. This change in transparency I have found also well exhibited in some beautifully preserved spicules from the Upper Chalk which I hope soon to describe; these can scarcely be discerned when viewed in balsam, but are seen very clearly in the less-refractive medium. The different appearance of spicules in these different media suggested to me that a corresponding advantage might be gained by mounting recent spicules in glycerine jelly; but on following out this idea I found my recent spicules were quite, or at all events nearly, invisible in this material, from which one draws the conclusion that the recent spicules have a refractive index corresponding closely with the lower one of glycerine jelly instead of with the higher one of Canada balsam, and hence, first, that recent spicules are not themselves seen in Canada balsam, but only their negative images or optical casts, and, next, that in process of time the refractive index of spicular silica undergoes an elevation approximately equal to that of passing from the refractive index of glycerine jelly to that of Canada balsam.

Change from the Colloid to the Crystalline State.—The alteration in the refractive index would naturally accompany a change of the original silica of the fibre from a colloid to a crystalline condition; and that such a change has certainly taken place can readily be proved by examining the network as previously prepared, or in an ordinary transparent section, by polarized light. When this is done, a change in the plane of polarization is distinctly produced by the fibre, since it shines out with faint bluish and yellow glimmerings on the dark ground produced by crossed prisms. If now some recent spicules, or some compound Vitreohexactinellid fibre, be substituted for the fossil silica, no effect will be produced on the light: the dark ground will remain wholly dark; and if the polarizer be turned round 90°, the light admitted will undergo no change of colour in passing through the object.

One may diverge for a moment here to speak of some additions to the modes of examining recent sponges which arise out of these observations. First, the fact that the recent spicule is almost invisible in glycerine jelly, while the horny fibre of sponges is more than usually well defined in it, allows us to optically *despiculize* the fibres of the Chalinida and Echinonemata (Carter) by immersing them in this substance, and thus to observe the kerataceous material independently; and, next, the fact that the calcareous spicules of the Calcispongiæ do produce a marked effect on polarized light, exhibiting brilliant colours, which siliceous spicules and fibre do not, provides us with a speedy method of distinguishing between these two kinds of spicules, and one which may be employed in cases where the use of acid is not available*.

I cannot attempt to explain all the various mineral changes and replacements which we have now described; they are as obscure as most of the pseudomorphic alterations which occur in fossilization; but two most important facts stand out from all the rest in my mind:—first, that siliceous fibre may be completely replaced by carbonate of lime without obliterating its structure; and, next, that spicular silica may with lapse of time pass from the colloidal to the crystalline state.

Alliances.—In looking for the existing relations of *Stauronema* one will not find any near ones. The absence of a "lantern" about the nodes excludes the Ventriculites; *Euplectella* is characterized by ladder-formed fibre, and is in most respects widely divergent. With *Aphrocallistes* the oscular plate presents some analogy, as pointed out to me by Mr. Carter, the walls of the tube-net of *Aphrocallistes* being perforated completely by horizontal excurrent canals quincuncially arranged, just as we found in the plate-net of *Stauronema*; and even, as in the latter the oscules become covered up with a layer of fine network, so a network, but not correspondingly fine, extends itself over the oscules of *Aphrocallistes*, as may

* Mr. Carter points out to me that this latter observation has been previously made by O. Schmidt.

be clearly seen in a specimen which Mr. Carter kindly sent me to illustrate this point. The skeletons of the two, however, are in one respect widely different. In *Aphrocallistes* the imbedded sexradiates are subject to great variations in the disposition of their rays, five, or even all six, radii being sometimes brought into one plane, while two or more of these rays may be and often are enveloped in one and the same fibre; so that the nodes of the resulting network are as often as not sexrotulate in the same plane, and the intermeshes consequently triangular. In *Stauronema*, on the contrary, the spicule maintains a rigid stereometry, never departing from a rectangular triaxial type, and the rete is usually quadrangular; and though it may vary in this respect, yet when it does so the change is never due to the departure of any radius of the original spicules from strict rectangularity, but results from a different disposition of the entire spicules with regard to one another. This difference is seen in the following diagrams:—

Fig. 8.

Fig. 9.

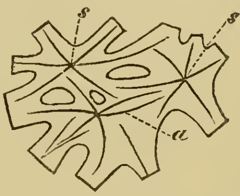


Fig. 8 shows quinqueradiate nodes (*q*) of *Stauronema*, due to the relative disposition of the spicules (*s*).
Fig. 9 shows the quinque- and sexradiate nodes of *Aphrocallistes*, and the sexradiate spicules (*s*) with rays making various angles with each other. At *a* two rays of a spicule are seen lying approximately parallel and imbedded in the same fibre.

In this character *Stauronema* agrees with *Farrea occa*, where also we find the same persistency in the form of the skeleton-spicule; and to this example may be added the external net of *Eubrochus* (Sollas) and the Ventriculitidæ generally. But, as we have said, the Ventriculites are excluded by the presence of the lantern about the nodes; and *Farrea* is so of course by the fact that its skeleton consists of but a single layer of lattice-work; *Eubrochus* exhibits a more delicate and less regular internal skeleton, and is altogether a very different sponge.

The place of *Stauronema* amongst its relations may perhaps be best illustrated by the following Table, which is a classification of the Vitreohexactinellidæ according to the characters of their skeletal network.

I. Sexradiate skeleton-spicule always rectangular. STAURONEMATA.

(*a*) Skeletal network with simple nodes
(1) one layer in thickness .... *Farrea.*
(2) several layers thick .... *Stauronema.*

(*b*) Skeletal network having the nodes complicated by the presence of an octahedral lantern about each one .... *Ventriculitidæ*, including *Myliusia Grayi.*

II. Sexradiate skeleton-spicule with rays making any angle with each other. APHROCALLISTIDÆ.

Aphrocallistes, *Dactylocalyx**, *Iphiteon**, *Stromatopora* (*Callodictyon*, Sollas, n. g.) *concentrica.*

III. Skeleton-spicules cemented into ladder-like fibre. EUPLECTELLIDÆ.

Euplectella, *Sympagella.*

Vitreohexactinellidæ.

Genus STAURONEMA (mihi).

Form half-conical or half-cup-like, fan-shaped, vertical, sessile, attached.

Structure a thin oscular plate, overgrown at its base by a thick posterior mass. *Oscules* oval or round, quincuncially arranged, patent where the oscular plate is free, concealed beneath a superficial reticulation where attached. *Excurrent canals* cylindrical where they perforate the oscular plate.

Skeleton: spicule triaxial, axes at right angles to each other; fibre robust, nodes sexradiate, meshes quadrilateral.

Formation. Gault and Upper Greensand†.

Locality. Folkestone and the Isle of Wight.

Species:—

1. *Stauronema Carteri* (mihi), type.

Form. Posterior mass more or less rugose horizontally, extending as far as the lateral edges of the plate to which it is attached (see p. 6).

Remark. This species I dedicate with great pleasure to my friend and instructor Mr. H. J. Carter, who was the first to explain aright the structure of the vitreohexactinellid skeleton.

* The imbedded spicules of these two genera have not yet been observed; but the character of the network agrees with that of *Aphrocallistes.*

† I possess a specimen from the Upper Greensand of the Isle of Wight, which evidently belongs to this genus; but it is not well enough preserved for specific determination.

2. *Stauronema lobata* (mihi).

Form. Posterior mass not extending laterally as far as the lateral edges of the attached oscular plate, seldom or never ridged horizontally, usually lobed vertically into two or more diverging processes.

Oscules smaller than in *S. Carteri.*

Remark. This species is characterized by a more variable and less regular form than *S. Carteri.*

EXPLANATION OF THE PLATES.

Plate I.

[All the figures of this plate represent the objects of their natural size.]

Figs. 1 to 4. *Stauronema Carteri.*

Fig. 1. An average-sized specimen, anterior aspect: *o*, oscular plate; *p*, posterior mass; *s*, seam or line of division between the two.

Fig. 2. Same specimen as fig. 1, posterior view: *b*, base; *o*, posterior face of projecting oscular plate; *e'*, excurrent canal crossing oscular plate, shown on a fractured surface; *s' s'*, line of termination of posterior mass against the oscular plate.

Fig. 3. A smaller specimen, anterior view.

Fig. 4. Same specimen, posterior view: *b*, base.

Figs. 5 to 8. *Stauronema lobata.*

Fig. 5. Anterior view of a medium-sized specimen: *p'*, a lobe projecting from the posterior mass.

Fig. 6. Posterior view of preceding specimen: *b*, a fragment of attached "coprolite."

Fig. 7. Posterior view of a specimen showing the diverging lobes of the posterior mass, with the oscular plate visible between them.

Fig. 8. A very gently curved, almost flat specimen, showing the free surface of the oscular plate with its pore-areas.

Fig. 9. Free sponge-plate: *l–n*, simple outline of its surface; *n n n*, original margin (the remaining edge is a broken one); *a*, detailed representation of the oscular markings which cover the whole surface of the plate.

Plate II.

Fig. 1. Transverse section through *Stauronema Carteri*: *o*, oscular plate; *p*, posterior mass; *a*, *b*, & *c*, directions along which other sections were made through the same specimen—*a*, longitudinal, *b* & *c*, parallel sections; *e* & *e'*, excurrent canals. Nat. size.

Fig. 2. Longitudinal section through the centre of another specimen of *S. Carteri*: *o*, *p*, *e*, & *e'*, as in fig. 1; *d*, distal edge of oscular plate; *r*, outline in section of ridges formed by an accumulation of the superficial network. Nat. size.

Fig. 3. Parallel section through the oscular plate along the line *c* in fig. 1. Nat. size.

Fig. 4. Skeletal network of oscular plate, magnified from fig. 2: *a*, margin of fibre, transparent as far as *b*, where it becomes granular;

s, cast of sexradiate spicule filled more or less completely with iron pyrites; *l*, diverging longitudinal, and *t*, curved radiating fibres. ×30.

PLATE III.

Fig. 1. Fibre surrounding an oscule, from a specimen which has been etched with acid, seen by reflected light: *s*, one of the projecting spines. ×30.

Fig. 2. Section along an excurrent canal of the oscular plate, after etching with acid, seen by reflected light: *r*, fine superficial network roofing over the oscule; *p*, fibre produced from it, depending into the canal; *q*, small irregular fibres growing out from the skeletal network. The arrow indicates the original course of the outflowing current. ×30.

Fig. 3. Surface of oscular plate near one of the concealed oscules: *s*, coarse skeletal fibres, smaller than in the interior of the plate, spined, and passing under *r*, the secondary rete. ×60.

Fig. 4. A mesh of the outer skeleton-fibre, giving off at its margins some of the fine superficial network. ×140.

Fig. 5. A part of the oscular plate represented in Pl. II. fig. 3, magnified to show:—*a*, an acerate spicule imbedded in the network; and *b*, part of an abnormally fine skeletal network, a band of which traverses the whole of this specimen of the oscular plate. ×30.

PLATE IV.

Fig. 1. Secondary rete, seen by reflected light: *f*, fibres parallel with the surface; *s*, free spinose ends of fibres normal to the surface. ×104.

Fig. 2. Projecting spinose fibres (*s* of fig. 1), resembling the fir-cones of *Farrea occa*. ×104.

Fig. 3. Similar to fig. 1, but showing a finer meshwork. ×104.

Fig. 4. Fine superficial network, seen near the base of the oscular plate by reflected light, where it conceals the spinose fibres of fig. 2. ×104.

Fig. 5. Similar network, but occurring between the spines of fig. 2. The sexradiate arrangement of the fibres is well seen in this instance. ×104.

Figs. 6 & 7. Minute sexradiate reticulation proceeding from the spinose ends of fig. 2. ×104.

PLATE V.

Fig. 1. Superficial network from the surface of the posterior mass: *m*, intermesh; *f*, fibres; *n*, secondary intermesh. ×60.

Fig. 2. A part of fig. 1, more highly magnified, showing the compound nature of the fibre. ×190.

Fig. 3. Network beneath fig. 1, consisting of *f*, large fibres, the meshes between which are webbed with the fine fibrelets, *g*. ×140.

Fig. 4. Fragment of superficial network from anterior face of same specimen, showing clearly a sexradiate arrangement. ×140.

Fig. 5. Entirely spined cylindrical spicule, projecting from the face of the oscular plate. ×140.